

**SECTION 50****MAIN AND AUXILIARY MACHINERY**

<b>1</b>	<b><u>ITEM</u></b>	<b><u>PAGE</u></b>
2	<b>50.1 REFERENCES .....</b>	<b>1</b>
3	<b>50.2 INTRODUCTION .....</b>	<b>2</b>
4	<b>50.3 GENERAL .....</b>	<b>2</b>
5	<b>50.4 PROVEN PERFORMANCE REQUIREMENTS .....</b>	<b>3</b>
6	<b>50.5 MACHINERY PLANT CONFIGURATION AND INTEGRATION .....</b>	<b>3</b>
7	<b>50.6 MACHINERY SPACE NOMENCLATURE AND ARRANGEMENT .....</b>	<b>4</b>
8	50.6.1 COMPARTMENT NOMENCLATURE .....	4
9	50.6.2 GENERAL ARRANGEMENTS .....	5
10	50.6.3 WALKWAYS .....	7
11	50.6.4 MAINTENANCE ACCESS .....	8
12	50.6.5 SHIPPING ACCESS AND SERVICE ROUTES .....	8
13	<b>50.7 VIBRATION AND NOISE CONTROL FEATURES .....</b>	<b>9</b>
14	<b>50.8 ENGINEER OPERATING STATION (EOS) .....</b>	<b>9</b>
15	<b>50.9 COMPONENT REMOVAL ZONES .....</b>	<b>10</b>
16	<b>50.10 LIFTING GEAR .....</b>	<b>11</b>
17	<b>50.11 LIFTING PADEYES .....</b>	<b>12</b>
18	<b>50.12 MACHINE GUARDING .....</b>	<b>12</b>
19	<b>50.13 PROPULSION SYSTEM ALIGNMENT .....</b>	<b>13</b>
20	50.13.1 METHOD .....	13
21	50.13.2 RUN-OUT .....	13
22	50.13.3 COLD ALIGNMENT CHECK .....	13
23	50.13.4 HOT ALIGNMENT CHECK .....	14
24	<b>50.14 TRAINING .....</b>	<b>14</b>
25	<b>50.15 SPARE PARTS AND INSTRUCTION MANUALS .....</b>	<b>15</b>
26	<b>50.16 TESTS, TRIALS AND INSPECTIONS .....</b>	<b>15</b>
27	<b>50.17 PHASE II TECHNICAL PROPOSAL REQUIREMENTS .....</b>	<b>16</b>
28	<b>50.18 PHASE III DETAIL DESIGN AND CONSTRUCTION REQUIREMENTS .....</b>	<b>16</b>
29	<b>50.1 REFERENCES</b>	
30	<b>(50A) VOLUME V, OWNER - FURNISHED EQUIPMENT</b>	

(50B) OCCUPATIONAL SAFETY & HEALTH ADMINISTRATION - OSHA 1910 –  
Subpart O – *Machinery and Machine Guarding*

(50C) OSHA Publication 3067 *Concepts and Techniques of Machine Safeguarding*

(50D) Washington Administrative Code, CH 296-24, Part C, *Machinery and Machine  
Guarding*

## 50.2 INTRODUCTION

This Section contains the Contractor Design and Provide general requirements applicable to the complete machinery plant, and supplements requirements in other Sections covering systems and component parts of the plant.

***For WSF Fleet-wide Standardization purposes, End No. 1 of the Vessel shall always be considered the bow, and this designation shall delineate port and starboard, fore and aft wherever they are addressed in the Technical Specification.***

## 50.3 GENERAL

The machinery plant shall be designed to properly operate under the range of interior and exterior environmental conditions to which it may be exposed. “Properly operate” as used herein shall mean that all components will perform their intended functions within manufacturer’s design parameters throughout their design operating ranges. Irrespective of the aforementioned requirement and unless otherwise specified for particular items, all systems and equipment shall also be rated for interior ambient air temperatures of no less than 122F degrees.

To meet the requirements of the OFE equipment provided by the PSI Contactor under separate Contract, the “*EOS/Workshop area*” level, as defined in the *GENERAL* Subsection in Section 12 of the Technical Specification, shall be established at the 14'-0" level ABL, Port and Starboard. See the *OTHER KEY DIMENSIONS* Subsection in Section 1B of the Technical Specification.

The type and rating of each machinery plant component shall be compatible with its service demand. Its size, weight and complexity shall be held to a minimum consistent with reliable and economical operation and maintenance. Ratings of prime movers shall be sufficient to ensure that operation of the prime movers in an overloaded condition will not be required to drive the respective machinery plant components at their rated conditions.

Engines, oil-fired water heater, and fuel oil handling equipment shall have been designed by the respective manufacturers for use with ASTM D975, Grade Low Sulfur No. 2-D diesel oil.

The Contractor shall provide **all** fluids for **all** machinery and equipment whether the machinery and/or equipment is provided by the Contractor or is Owner - Furnished Equipment (OFE) up to the point of Vessel delivery to WSF, as set forth in the *GENERAL* Subsection in Section 101 of the Technical Specification. Fluids for machinery and/or equipment shall be of the type specified by the manufacturer.

All machinery requiring lubricating or hydraulic oils shall be supportable using current WSF lubricant contract products at the time of installation. Manufacturer's recommendations for lubricants shall identify the acceptable product.

The machinery plant shall operate over its entire operating range without exceeding noise and vibration limitations specified in Section 102 of the Technical Specification.

Emissions from machinery shall meet the air and water pollution control standards and regulations of the cognizant local, State, and Federal Authoritative Agencies as listed in Section 1 of the Technical Specification.

Maintenance that should be accomplished underway shall not compromise the ability to maintain propulsive power on both shaft lines. The design, configuration and arrangement of machinery, equipment and systems shall account for this requirement.

After tests and trials, and just before the ship is delivered, all strainers shall be cleaned, all filter elements shall be replaced with new filters, and all systems' hydraulic and lubricating oils shall be changed.

#### **50.4 PROVEN PERFORMANCE REQUIREMENTS**

See Reference (50A) for Owner - Furnished Equipment (OFE).

All of the following listed equipment items shall be shown to have proven satisfactory performance in previous marine installations.

- A. HVAC Systems (exclusive of the control system)
- B. Oil-fired Hot Water Heater
- C. Steering Gears

Items of equipment listed above shall not be one of the first six (6) units manufactured and/or assembled at a production facility.

#### **50.5 MACHINERY PLANT CONFIGURATION AND INTEGRATION**

The operating voltages of electrical systems shall be 480 Vac, 208 Vac, and 120 Vac, both 3-phase and single-phase power. Control voltages shall generally be 120 Vac and 24 Vdc.

*The Propulsion System Integration (PSI) Contractor, under the direction of the WSF Representative, will oversee and assist as the Contractor's "technical point-of-contact" (TPOC) regarding the design, integration, installation, interface (of the Propulsion and AMS Systems with all electrical power generation and distribution systems), and testing of the entire propulsion plant (controls and drive train (engines through propellers) and AMS).*

*The Ship's Service Diesel Generator (SSDG) Contractor, under the direction of the WSF Representative, will oversee and assist as the Contractor's "technical point-of-contact" (TPOC) regarding the design, integration, installation, interface (of the SSDGs and Emergency Diesel Generator with all electrical power generation and distribution system), and testing of the entire power generation plant (main movers, alternators, and controls).*

*The PSI Contractor and the SSDG Contractor shall also participate in an advisory capacity in the Contractor's selection of related machinery and equipment.*

**BE ADVISED:** The Contract Bid Support Package provides OFE documents and drawings in Reference (50A) that contain specific installation instructions setting forth mandated installation procedures and precautions. The Contractor shall provide designs and installations that, at a minimum, meet and address all instructions and requirements as set forth in the OFE documents and drawings.

## **50.6 MACHINERY SPACE NOMENCLATURE AND ARRANGEMENT**

### **50.6.1 Compartment Nomenclature**

The space containing the Owner - Furnished Equipment (OFE) (*WSF provided*) Main Engines shall be designated "Engine Room No. 1" or "Engine Room No. 2", as appropriate. The spaces containing the ship's service diesel generators shall be designated "Engine Room No. 1" (SSDG No.1 and No. 2); or "Engine Room No.2" (SSDG No. 3 with acoustic enclosure), as appropriate.

The spaces containing the OFE provided reduction gears shall be designated "Reduction Gear Room No. 1" or "Reduction Gear Room No. 2", as appropriate.

The spaces containing the potable water tanks and the sewage tanks shall be designated "Tank Room No.1" or "Tank Room No. 2", as appropriate.

The spaces containing the inner stern tube seals shall be designated "Void No. 1" or "Void No. 2", as appropriate.

The spaces containing the steering gears shall be designated as "Steering Gear Room No. 1" or "Steering Gear Room No. 2", as appropriate.

1 The space containing SSDG No. 3 shall be designated as “SSDG No. 3 Acoustic  
2 Enclosure.

3 The 14'-0" level Port side space containing the equipment spare parts storage shelving,  
4 lower end of the Crew Stairtower, ship's stores access hatch, service sink, and access to  
5 Water Tight Doors (WTD) No. 3 and No. 4 shall be designated the “Engineer's Stores”.  
6 This space shall also serve as a “sound vestibule” reducing the amount of Engine Room  
7 noise caused by open WTD's that reaches the Workshop and EOS spaces.

8 The 14'-0" level Starboard side space containing the engineering crew lockers, bunker  
9 gear storage area, consumable items storage shelving, Vehicle Deck sprinkler valve  
10 manifold, Hi-Fog fire suppression system pump unit, and EOS deck air handler, shall be  
11 designated the “Crew Locker Room/Stores”.

12 The space containing the tool boards, work benches, engine lathe, milling machine, drill  
13 press, grinder, and tool storage lockers and shelves shall be designated the “Workshop”.

14 The space containing the EOS console, the log desks, and the ship service switchboard  
15 shall be designated the “Engineer's Operating Station” (EOS).

16 The space containing the lavatory sink/vanity, water closet, clothes washer, clothes dryer,  
17 changing bench, and shower stall shall be designated the “Engineer's Restroom”.

18 The space containing the kitchen sink, kitchen cabinets, stove, refrigerator, dishwasher,  
19 and seating booth with table shall be designated the “Engineer's Day Room”.

20 The space near the “Engineer's Dayroom” containing the floor mop, mop bucket, brooms  
21 and dustpans shall be designated the “Engineer's Cleaning Gear Locker”.

22 The space entirely within the confines of Engine Room No. 1, between the Fuel Oil Day  
23 Tank and the Port Fuel Oil Storage Tank containing the center sections of the high speed  
24 shaft and Fuel Oil Overflow Tank shall be designated the “High-Speed Shaft Alley”.

## 25 **50.6.2 General Arrangements**

26 Upper, mid, and lower levels shall be provided in the Engine Rooms. Walkway access to  
27 spaces fore and aft of the Engine Rooms shall be provided.

28 The Engineer Operating Station (EOS), Workshop, Engineer's Dayroom, Engineer's  
29 Stores, Crew Locker/Stores, and Engineer's Restroom shall be located on the (14'-0"  
30 level ABL) upper level between the two (2) Engine Rooms with direct emergency escape  
31 access to the Lower Vehicle Deck (Main Deck) as required by regulations. To the extent  
32 practicable, the EOS shall be located away from major noise and heat sources such as  
33 turbochargers. The EOS **shall not** be used as a primary route between other spaces.

A single level open walkway shall be provided, at the 14'-0" level spoken to above, between Reduction Gear Rooms No. 1 and No. 2 allowing for wheeled transport of equipment and supplies to all points in between. This walkway shall be a minimum of forty-eight (48) inches wide and pass through the watertight sliding doors covered in Section 4 of the Technical Specification.

To meet the requirements of the OFE equipment provided by the PSI Contactor under separate Contract, the SSDG No. 3 Acoustic Enclosure shall be located in Engine Room No. 2 on the Starboard side in order to maintain maintenance clearance around Main Engine No. 2. The combustion air filter for Main Engine No. 2 has been relocated to the high-speed shaft side to accommodate this clearance.

All of the following machinery, equipment and propulsion system components that are not otherwise located in the Engine Rooms shall be accessible from the Engine Rooms via walkways and doors and/or hatchways without having to go vertically to the Lower Vehicle Deck above:

- A. Reduction Gears
- B. Ship's Service Diesel Generator sets
- C. Oil-fired Hot Water Heater
- D. Fuel Oil Centrifuge and/or Filters
- E. Air Compressors and Receivers
- F. All Pump/Motor Sets serving Main Propulsion Machinery
- G. Sewage tanks
- H. Potable water tanks
- I. Line shaft bearings

The Engineer's Workshop and Engineer's Storeroom, and Crew Locker Room/Stores described above, and in Section 80 of the Technical Specification shall be located below the Lower Vehicle Deck (Main Deck) and immediately adjacent one to the other within the same watertight boundary. These spaces shall be separate from, but immediately adjacent to and accessible from the Engine Rooms via primary walkways without having to go up vertically to the Lower Vehicle Deck.

For Engineer's Stores shelving requirements, see the *PORT AND STARBOARD ENGINEER'S STORAGE AREAS* Subsection in Section 80 of the Technical Specification.

In order to provide the most direct means of escape from the ***"EOS/Workshop area"***, the ladderway from the Port side "Engineer's Stores" to the lower Vehicle Deck and above, shall rise toward End No. 1 of the Vessel.

Space shall be provided in the Engineer's Restroom for the installation of the washing machine and dryer required by Section 18 of the Technical Specification.

Refer to Section 1 of the Technical Specification for additional general arrangement requirements.

### **50.6.3 Walkways**

Fore-and-aft and athwartship walkways shall be provided on both levels in the Engine Rooms and in all other spaces containing machinery and other equipment. These walkways shall be of sufficient extent and arranged to support the following functions:

- A. Passage between spaces.
- B. Machinery and equipment in-place maintenance and repair.
- C. Visual safety inspections of piping, machinery and other equipment, such as those performed during engineering rounds.
- D. The movement of machinery via shipping routes and through the maintenance access openings between the Reduction Gear Rooms, Engine Room(s), Engineer's Workshop, and Tank Rooms. (see Section 4 of the Technical Specification).

Primary walkways shall provide a clear path no less than 36 inches wide × 76 inches high throughout their length. The width shall be increased where necessary to properly service items adjacent to the walkway. Primary walkways shall be provided as follows:

- A. As the principal routes between spaces and to all doors and ladderways.
- B. Around the following items:
  - (1) Main Engines
  - (2) Reduction Gears
  - (3) Oil-fired hot water heater
  - (4) Ship's Service Generator Sets
- C. Along at least one (1) side of all principal equipment, including but not limited to, the following items:
  - (1) Fuel Oil Centrifuge and/or filters
  - (2) Air Compressors and receivers
  - (3) Air Conditioning and Refrigeration units
  - (4) CPP distribution box
  - (5) All pump/motor sets
  - (6) Plate Coolers

(7) Manifolds

(8) Fire Fighting Equipment

Secondary walkways are considered to be any walkways that are not considered primary walkways defined above, such as “dead end” walkways terminating at bulkheads, side shell, or other obstruction. To the extent practicable, secondary walkways shall be of the same clear path dimensions as primary walkways, but may have reduced clear width and height where necessary to accommodate pipe runs and other interferences.

There shall be clear walkways down both sides of the engine at the top of the skid height for maintenance and inspection purposes. The minimum clear width of the walkway between each Main Engine and the high speed shaft shall be twenty-four (24) inches. It is the intent of the OFE design that no high-speed shaft bearings or bearing foundations shall be located at any point alongside the entire length of either Main Engine.

#### **50.6.4 Maintenance Access**

Maintenance access shall be provided around **all** equipment and machinery requiring periodic servicing. Access to sensing and control devices, filters and similar components in fan rooms shall be given particular attention.

Ladders and platforms shall be provided within the casing, allowing suitable access for purposes of maintenance and inspection to the combustion engine silencers, expansion and mechanical joints, piping systems, and other items installed in the casing.

It shall be possible to remove, replace a steering motor and/or pump assembly, and replace/adjust the feedback potentiometers that are located on the back side of the rotary steering gear without the necessity of removing any access hatches. Steering Gear Room hatches required for space access shall not be located in any vehicle lane.

In order to gain immediate access from the EOS and up through the Crew Stairtower, the Emergency Diesel Generator Room shall be accessed directly through a door in the Crew Stairtower at the Sun Deck level. To comply with regulatory requirements it shall also be accessed directly through a door in the exterior (weather) bulkhead surrounding the Emergency Diesel Generator Room. In order to reduce noise levels in the crew accommodation block, there shall be no door into the Emergency Diesel Generator Room from the interior of the crew accommodation block.

#### **50.6.5 Shipping Access and Service Routes**

Shipping routes shall be provided for removing from throughout the Vessel the various machinery and equipment items. For very large machinery and equipment items, such as Main Engine blocks, Reduction Gears, and the Oil-fired hot water heater, such routes shall be via welded patches in decks and bulkheads.



Care shall be taken to avoid obstructions to the removal and shipping of machinery and equipment. **In no case** shall cableways or other substantial obstructions be located in way of intended shipping routes. Where piping, ductwork or other interferences cannot practicably be routed in a manner that avoids interference, suitable take-down joints or similar features shall be incorporated to make the interference readily removable.

Service routes shall be provided to move machinery components between the Engine Room(s) and the Engineer's Workshop. These routes shall be served by primary walkways and the bulkhead access openings described in Section 4 of the Technical Specification.

## **50.7 VIBRATION AND NOISE CONTROL FEATURES**

The Main Engines skids, all diesel generator sets, air compressors, air conditioning and refrigeration compressors, fans and blowers shall be installed on resilient mounts. The Main Engine skids and Ship's Service and Emergency Diesel Generator set mounts will be OFE in accordance with Reference (50A). Vibration-sensitive electrical and electronic equipment shall be installed on resilient mounts as recommended by the equipment manufacturers and as otherwise deemed appropriate. Other components shall also be resiliently mounted as necessary to attenuate the transmission of noise and vibration to meet the requirements of Section 102 of the Technical Specification. For additional Main Engine requirements, see Section 51 of the Technical Specification.

## **50.8 ENGINEER OPERATING STATION (EOS)**

An Engineer Operating Station (EOS) shall be provided, located in accordance with the *MACHINERY SPACE NOMENCLATURE AND ARRANGEMENT* Subsection in this Section of the Technical Specification. The EOS shall be no less than as set forth in the *MATRIX OF SPACES* Subsection in Section 1B of the Technical Specification, including the space taken up by consoles, switchboards, furnishings and other installed items, and shall be suitably configured to accommodate four (4) persons.

The EOS shall be totally enclosed with steel bulkheads, overhead and deck. These boundaries, and their openings, shall be fitted with acoustic treatments incorporating high transmission loss materials as set forth in Section 7 of the Technical Specification, and of types and thicknesses suitable for meeting the 70 dB(A) maximum sound pressure level criterion specified in Section 102 of the Technical Specification. See Section 6 of the Technical Specification for deck treatments.

Portlights, windows, and access openings shall maintain the acoustic rating of the boundary.

The doors between the EOS & Chief Engineer's Office and the Workshop shall be provided with magnetic door holdback systems.

The EOS shall contain at a minimum the Contractor supplied Ships Service Switchboard and the following OFE equipment: EOS Control Console, Pneumatic Propulsion Control Enclosure, Electronic Propulsion Control Enclosure, End No. 1 AMS Remote I/O Panel, and End No. 2 AMS Remote I/O Panel.

The OFE EOS Control Console is designed with a specific orientation that shall be accommodated by the Contractor. The long axis of the Control Console shall align fore and aft over the high speed shaft alley to allow for bottom entry of control cabling from the Engine Rooms. When standing in front of and facing the propulsion controls, the right hand end of the Control Console shall point towards the End No. 1 of the Vessel. Without moving away from this position in front of the console, the operator shall be able to see into both Engine Rooms, owing to proper alignment of the EOS door and the A-60 watertight bulkhead windows or portlights.

The number of stanchions in the EOS shall be minimized and incorporated into enclosing bulkheads or joiner panels wherever possible.

The minimum unobstructed clearance in front of and behind the EOS Control Console shall be 36" and 32" respectively. The minimum unobstructed clearance in front of the Electronics Propulsion Enclosure and the Pneumatic Propulsion Control Enclosure shall be 40" and 32" respectively. The minimum unobstructed clearance in front of and behind the Ship Service Switchboard shall be 36" and 32" respectively, except that a stanchion shall be allowed in front, if it does not obstruct the hinged front panel swings.

Instrumentation installed on the front panels of the Pneumatic Propulsion Control Enclosure and the Electronics Propulsion Control Enclosure shall be visible by the operator both while standing at the propulsion controls or when seated at either log desk.

Furnishings shall be provided in the EOS in accordance with the Furniture Schedule of Section 19 of the Technical Specification.

For deck coverings and acoustic flooring requirements see Section 6 of the Technical Specification.

## **50.9 COMPONENT REMOVAL ZONES**

The Contractor shall design and provide component removal zones and accesses connecting each rail and trolley system from the point of installation to temporary storage locations on the floor plates, and on to quick release, lockable plate access openings in the Lower Vehicle Deck and/or sides of the machinery casing to allow for shipping the component to the Vehicle Deck where it can be moved to and/or removed from the Vessel. The size of each opening shall be set by the governing component needing to be removed. The location, size, and number of these SOUTHCO, or equal, quick release, lockable plate component removal access zones shall be shown on the all Working Drawings and shall be approved by the WSF Representative.

## 1    **50.10 LIFTING GEAR**

2    In addition to special lifting guides, jacks and supports furnished by manufacturers of  
3    machinery plant components, lifting gear shall be designed and provided to service, remove  
4    and overhaul machinery components and piping systems.

5    An overhead rail and trolley system shall be provided in each Engine Room with rails over  
6    each engine cylinder bank, turbocharger, and SSDG prime mover. Each rail and trolley  
7    system shall be designed to lift and transport each cylinder bank, turbocharger, and/or SSDG  
8    prime mover or alternator component from the point of installation to temporary storage  
9    locations on the floorplates, and/or sides of the machinery casing to the Lower Vehicle Deck  
10    (Main Deck). There shall also be a small pneumatic motorized parts transfer "jib style"  
11    crane provided and located at the upper level of each Engine Room to allow for the transfer  
12    of parts from the lower Engine Room level to the upper Engine Room level, where the  
13    equipment can be transported back to the "Engineer's Stores" area located on the same level  
14    as the EOS. The motorized jib crane shall be rated at a minimum of 1,000 pounds.

15    An overhead rail and trolley system shall be provided in each Reduction Gear Room with  
16    rails over each Reduction Gear. The rail system shall run both athwart ship, and fore and aft,  
17    to allow components to be moved in either direction. Each rail and trolley system shall be  
18    designed to lift and transport Reduction Gear upper casing covers and pinions from the point  
19    of installation to temporary storage locations on the floorplates.

20    An overhead rail and trolley system shall be provided in the Engineer's Workshop as set  
21    forth in Section 80 of the Technical Specification.

22    An overhead rail and trolley system shall be provided for the Engineer's Stores provisioning  
23    opening as set forth in Section 80 of the Technical Specification.

24    All rails shall be interconnected with curved sections and switches to accommodate use of  
25    trolley hoists. Each rail and trolley system shall have rail stops and latches for stowage of  
26    the hoists at an unobtrusive location. Suitable means shall be provided to expediently  
27    remove any interferences in way of the trolley's path.

28    At least one (1) pneumatic hoist or chain hoist, as set forth in Section 80 of the Technical  
29    Specification shall be provided on each rail system. Each hoist shall have a capacity suitable  
30    for the heaviest component to be lifted in the space. The quantity of hoists provided shall be  
31    sufficient to service all machinery in the space without requiring manual transfer of a hoist  
32    from one (1) rail system or section rail to another. Hand hoists shall be YALE LOAD  
33    KING, or equal.

34    The Contractor shall demonstrate the removal capability of the Engine Room trolley systems  
35    as set forth in the *SSDG Removal Demonstration* and *Main Engine Turbocharger Removal*  
36    *Demonstration* Subsections in Section 101 of the Technical Specification. All lifting  
37    equipment, rails, jibs and associated weight bearing equipment shall be weight tested as  
38    required by Section 101 of the Technical Specification.

Padeyes, or in some areas suitable mountings for clamps, shall be provided in number, location and capacity as necessary along shipping and service routes to facilitate the movement of machinery and equipment as set forth in this Subsection and the *LIFTING PADEYE* Subsection below.

#### **50.11 LIFTING PADEYES**

Padeyes shall be installed over all machinery, equipment, or component weighing more than fifty (50) pounds and as detailed in Sections 2, 5, 50, 53, 59, and 80 of the Technical Specification. Each padeye shall be designed for two (2) times the load it will be required to hold, but not less than 3,000 pounds. Test each padeye to 1½ times its rated load and provide a written report of each test to the WSF Representative.

Provide permanently installed metal labels, in accordance with this Section and Section 24 of the Technical Specification, at each tested site which states the rated load, test load applied, the date tested, and the identity of the testing facility or individual.

#### **50.12 MACHINE GUARDING**

The Contractor shall design and provide guards for the high speed propulsion shaft, all rotating machinery, power-transmission machinery, and other machinery where necessary to prevent personnel from contacting moving parts or extreme temperatures. Equipment hazards to be guarded shall include, but are not limited to, flywheels, couplings between motors and pumps, "V" belt drives, turbochargers, and exhaust pipes. The Contractor is responsible for ensuring that all machinery is guarded or protected in accordance with References (50B), (50C), and (50D). Where the equipment manufacturer does not provide adequate guarding, the Contractor shall be responsible for providing proper guarding. The PSI Contractor will provide shaft guards for the high speed input shafts between the Reduction Gear input side, and the bulkhead between the Reduction Gear Room and Engine Room, for adaptation and installation by the Shipyard as Contract base work.

The high-speed propulsion shaft guard design in way of the Main Engines shall be approved by the WSF Representative prior to fabrication. It is the intent to have the guards designed to maximize the clearance between the guard and the side of the Main Engine.

The high-speed shaft guards shall not obstruct or be attached to any part of the high-speed shaft bearings or bearing foundation bolts. It is the intent to have clear access to these bearings for maintenance and inspection without the necessity for guard removal.

Provide bolted attachment of the guards to the machine bases or foundations utilizing corrosion resistant studs, bolts, nuts, and washers.

### **50.13 PROPULSION SYSTEM ALIGNMENT**

The Propulsion System shall align properly when the Vessel is waterborne in its fully outfitted and properly ballasted state, with all components installed, connected and supported in their respective bearings. The Shipyard shall work closely with the PSI Contractor and WSF to establish proper alignment limits and procedures. "Proper alignment" is defined as the positioning of the system such that bearing loads, system clearances and other salient characteristics fall within the pre-established design tolerances and limits under all conditions, with due regard to thermal growth, bearing wear-down, hull deflections and other effects. The shafting system shall be aligned such that the gear fore and aft bearing load differential is within that set by the gear manufacturer and all bearing loads are well below the maximums established by the respective manufacturers for the design bearing life.

The Propulsion System alignment shall be performed under the direct supervision of personnel experienced in and regularly engaged in alignment of Vessel shafting using strain gages.

Final alignment of the shafting shall be checked in both the cold and hot conditions as follows:

#### **50.13.1 Method**

The strain gage method shall be used to determine both vertical and horizontal bearing loads for all bearings, including the bull gear bearings. The number and location of strain gage measurement points shall be sufficient to ensure that minor measurement errors at one location will not unduly affect the results at other locations. Full WHEATSTONE bridges, consisting of four (4) strain gages, shall be used at each location.

#### **50.13.2 Run-out**

Prior to installing strain gages, the shaft sections must be completely connected in their final state, and the run-out measured at each bolted coupling flange rim relative to the hull. Run-outs greater than 0.005 inch Total Indicator Reading (TIR) shall be corrected prior to installation of gages. The plane of strain gages shall be established 90 degrees from the plane of worst run-out.

#### **50.13.3 Cold Alignment Check**

Bearing loads shall be measured in the cold condition to the extent that assurance can be given prior to Sea Trials that the resulting hot alignment will meet the alignment criteria. Line shaft bearings shall be adjusted as necessary to achieve that assurance.

The cold alignment strain gage readings shall be validated using the Jacking Method at one or more bearing locations. If the strain gage and jacking method results differ by

more than 15-percent (15%), the discrepancy shall be corrected to the satisfaction of the WSF Representative.

#### **50.13.4 Hot Alignment Check**

Bearing loads shall be measured with the Engine Room foundations and Reduction Gear up to operating temperature, such as while undergoing or immediately upon returning from underway Sea Trials.

The revised Propulsion Alignment Booklet required by the *PHASE III DETAIL DESIGN AND CONSTRUCTION REQUIREMENTS* Subsection in this Section of the Technical Specification (both the original pre-alignment version and revised post-alignment version), and the associated shafting system alignment shall be subject to approval of the WSF Representative.

Alignment shall be coordinated to meet all the requirements of this Section, Section 51, Section 52, and Section 53 of the Technical Specification.

#### **50.14 TRAINING**

The Contractor shall develop and conduct hands-on training for the Vessel's personnel on each of the following systems/equipment:

- A. Hot Water Heating (Waste Heat Recovery) and Oil-fired Hot Water Heater.
- B. Steering Gears.
- C. Centrifuges/Purifiers.
- D. Heating, Ventilation and Air conditioning Systems.
- E. Lifesaving, Fire Fighting, Safety and Emergency Systems and Appliances.
- F. Any other Contractor provided equipment, system, and machinery.

Training for each item of equipment, systems, and machinery shall be as set forth in Section 1 of the Technical Specification. Except where explicitly stated otherwise for particular systems or equipment, training conducted at the place of delivery shall be provided by factory-certified representatives having previous teaching experience and thorough knowledge of the delivered equipment/system/machinery and its marine application.

Training shall cover operation, maintenance, overhaul and troubleshooting. Training shall include hands-on training with actual equipment, system, or machinery of the model series supplied under the Contract, in addition to appropriate classroom instruction. The training shall be scheduled to be completed at least fourteen (14) days, but no more than sixty (60) days, prior to the scheduled date of Operational Acceptance of the Vessel. The dates of training shall not coincide with the dates of Dock Trials or Sea Trials. Travel and per diem costs for the WSF personnel shall be borne by the Contractor.

As also addressed in Section 1 of the Technical Specification, lifesaving, fire fighting, safety and emergency systems and appliance training shall address maintenance and operation of the lifeboats, life raft embarkation slides, sprinkling and fixed fire extinguishing systems, as well as operation and location of the Vessel's alarms, fire dampers, fire doors and all other Vessel emergency safety features and appliances. This training shall be conducted by persons with appropriate knowledge of the attendant systems and appliances, but need not include representatives from each manufacturer. This training shall be formatted to include general safety familiarization training for all of the Vessel's personnel and maintenance training for sixteen (16) WSF personnel.

An "at sea" training period of at least twenty-four (24) hours duration shall be provided by the Contractor prior to delivery, with adequate representatives or Contractor personnel to demonstrate and train the Crew on lifesaving, ship handling, propulsion systems and mooring arrangements. The schedule and location of the at sea training is preferably at the port of delivery (Seattle area), prior to delivery; however, the details may be resolved when the transit schedule is prepared. The number of persons for this training shall be the normal Crew of the Vessel (approximately twenty-four (24)).

#### **50.15 SPARE PARTS AND INSTRUCTION MANUALS**

Provide a list of recommended spare parts and special tools for those items which are Contractor furnished, together with parts lists and instruction manuals necessary to maintain and service provided equipment and accessories in accordance with the requirements of Sections 86 and 100 of the Technical Specification.

#### **50.16 TESTS, TRIALS AND INSPECTIONS**

Machinery and equipment shall be shop tested by its manufacturer according to the applicable Section of the Technical Specification. Suitable written notification to the WSF Representative shall be made to allow the WSF Representative to witness the test. Documentation of shop testing shall be provided to the WSF Representative prior to any operation of equipment.

After installation, each machine and piece of equipment shall be tested in operation with its system to verify compliance to the Technical Specification and regulatory requirements.

Testing and/or trials shall be provided in accordance with this Section and Section 101 of the Technical Specification.

Inspections shall be performed as defined in this Section and Section 1 of the Technical Specification.

The Contractor, at no additional cost to WSF, shall correct any deficiencies or discrepancies noted during testing.

**50.17 PHASE II TECHNICAL PROPOSAL REQUIREMENTS**

The following deliverables, in addition to others required by Section 100 of the Technical Specification and the Authoritative Agencies, shall be provided during the Phase II Technical Proposal stage of Work in accordance with the requirements of this Section and Section 100 of the Technical Specification:

A. Shipping Routes Report

B. Resilient Mounts List

The *Shipping Routes Report* shall include:

A. Identification of the routes, accesses, and methods to be used to remove engines and other large machinery, the interferences to be removed, and hot work required. To the extent that the shipping of large machinery will require special consideration of the associated loading on ship structure, the necessary precautions and load distribution methods shall be addressed. Diagrams shall be included, as appropriate, to clearly identify the location and characteristics of access openings and describe the methods of effecting the shipping evolutions.

B. Identification of the various routes, accesses and methods to be used to remove machinery and equipment throughout the Vessel. Diagrams shall be included, as appropriate, to clearly identify the location and characteristics of access openings and to describe the methods of effecting the shipping evolutions.

The *Resilient Mounts List* shall define, for each equipment item to be installed on resilient mounts, the type of mounting (steel spring, elastomer, pneumatic, or other) and intended manufacturer of the mounting.

**50.18 PHASE III DETAIL DESIGN AND CONSTRUCTION REQUIREMENTS**

The following deliverables, in addition to others required by Section 100 of the Technical Specification and the Authoritative Agencies, shall be provided during the Phase III Detail Design stage of Work in accordance with the requirements of this Section and Section 100 of the Technical Specification:

A. Propulsion Alignment Booklet

B. Resilient Mounts Report

C. Machinery Log

D. Training Schedules and Syllabi

E. Purchase Specifications

A *Machinery Lifting Gear – Arrangement and Details* drawing is required in Section 100 of the Technical Specification and shall show lifting and moving arrangements for each part or



item of equipment weighing over 1,000 pounds (assembly weight) that will require installation or removal during the life of the Vessel, the weight of the part or equipment item to be installed or removed, and the safe working capacity of the lifting gear; the different slings and shackles shall be identified by part number. Lifting gear, including slings and shackles, may have multiple uses and need not be limited to a single piece of equipment. Drawings shall show details of lifting gear and shall include such notes as may be necessary to describe the operation of the gear or assembly of parts. Drawings shall also show the method of testing the lifting gear, including padeyes and lifting lugs, which are permanently installed in the Vessel or which must be dismantled to be removed from the Vessel. Calculations supporting the design and configuration of lifting gear shall be provided with the drawings. See Sections 5 and 101 of the Technical Specification.

***Miscellaneous Machinery Space Arrangement Drawings*** as required in Section 100 of the Technical Specification shall show piping systems, as necessary; ventilation ducts; and items of electric equipment, including main wireways to ensure against interference between mechanical and electrical components and to expose undesirable conditions whereby fluids from piping systems or moisture from ventilation ducts could be directed on electric equipment or main wireways. Machinery arrangement drawings shall also show other pertinent features such as major machinery foundations, tube removal space outlines, outlines of rail and trolley systems, unshipping of shafting, combustion air intake and exhaust systems, ladder landings and accesses, stanchions, overhead structure, bulkhead stiffeners and other hull structure necessary to indicate machinery obstructions, large piping such as propulsion cooling water piping, main sea connections and valves, location of removal plates for shipping gear and trolley arrangements, and locations of fire fighting equipment.

The ***Propulsion Alignment Booklet*** shall be prepared prior to commencing shafting installation. This booklet shall contain, as a minimum, the following:

- A. All Alignment Criteria (for example, tolerance values and limit values) that must be checked to confirm proper alignment of the propulsion system.
- B. A Shaft Alignment Drawing showing:
  - (1) Shafting details used in the shafting alignment analysis.
  - (2) Gear and shaft bearing locations, numbered sequentially forward to aft.
  - (3) Concentrated weights and their origin.
  - (4) A vertical alignment diagram showing installed bearing offsets from a straight line reference.
  - (5) Vertical and horizontal bench marks used to establish the shaft reference line.
- C. A Table of Bearing Reaction Influence Numbers giving the change in reaction, or load, of each bearing per unit vertical change in position with respect to itself and all other bearings in the system.

D. A Table of Bearing Loads expected for each bearing for the following conditions:

- (1) *Straight line*: The shaft centerline at all bearings set on a straight line.
- (2) *Recommended cold static alignment*: Bearings offset from a straight line to achieve the desired cold condition loads when supported in new, unworn bearings.
- (3) *Recommended hot, operating alignment*: Same as (2) above, but with the gear in its hot, operating condition.
- (4) *Worn-down, cold*: Same as (2) above, but with the strut bearing worn to its maximum wear-down allowance. Simultaneously, the stern bearing shall be assumed to wear as necessary to achieve projected area pressure equal to the strut bearing.
- (5) *Worn-down, hot*: Same as (4) above, but with the gear in its hot operating condition.

E. Tables of Bending Moment, Shear, Slope, and Deflection, and Plots of Deflection and Bending Stress for the two (2) hot conditions listed above.

F. Technical Documentation supporting the selection and/or derivation of gear and propeller concentrated weights, allowable setting error (ASE), and thermal growth/gear journal rise values used in alignment calculations.

G. Manufacturers' Data applicable to alignment and related calculations.

H. Alignment Procedures detailing the procedures to be used during the installation and alignment of the shafting and reduction gear to ensure that the alignment criteria will be met. Data sheets and other forms to be used during the alignment and validation proceedings shall be appended.

After the final alignment has been completed, the propulsion system alignment booklet shall be revised to include the as-measured hot and cold bearing loads, as follows:

- A. The measured bearing loads shall be used to estimate, insofar as possible, what the bearing offsets are relative to the straight reference line in both the cold and hot conditions.
- B. The Tables of Bending Moment, Shear, Slope, and Deflections, and the Plots of Deflection and Bending Stress shall be revised based on the hot condition calculated offsets.
- C. The Tables of Bearing Load shall be revised based on the calculated cold and hot offsets.

The ***Resilient Mounts Report*** shall fully describe the mounting system for each equipment item to be installed on resilient mounts. The report shall include for each mounting system, a drawing illustrating the equipment item, resilient mount configuration and details of mounts

1 and how they seat on the foundation. An accompanying analysis shall list machine weights,  
2 moments of inertia, mount make/model, mount loads and stiffnesses. The analysis shall also  
3 estimate the rigid body natural frequencies of the mounted system and the resulting  
4 transmissivity of the designed installation. For purposes of this analysis, foundations shall be  
5 assumed to be rigid. Frequency calculations do not need to be provided for fan and blower  
6 foundations.

7 A ***Machinery Log*** shall be maintained up to the time of Vessel delivery recording the dates  
8 and times that machinery and other equipment were operated. The log shall also include date  
9 and time entries for any transfers of oil or hydraulic fluids to and from machinery, any repair  
10 or maintenance work performed on machinery subsequent to initial start-ups, and any other  
11 information pertinent for record purposes. A separate log sheet shall be maintained of the  
12 accumulated hours on major machinery and other equipment.

13 ***Training Schedules*** and training session syllabi shall be provided for the training sessions  
14 required by this Section.

15 ***Purchase Specifications*** shall be provided for equipment to be supplied in accordance with  
16 the requirements of Section 100 of the Technical Specification.

(END OF SECTION)